Record of the largest specimen of neon flying squid *Ommastrephes bartramii* (Cephalopoda: Ommastrephidae)

Registro del mayor ejemplar de pota saltadora *Ommastrephes bartramii* (Cephalopoda: Ommastrephidae)

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ABSTRACT

We report a record of the largest known specimen of *Ommastrephes bartramii*. It was an almost mature female, with dorsal mantle length (ML) of 1020 mm and weighing around 35 kg, caught by a Spanish fishing vessel in October 2007 on a surface long-line in the Eastern Tropical Pacific. Growth increments on a statolith indicate an age of 492-512 days. The stomach was full and contained beaks of ommastrephid squids and of a small pelagic octopus (*Japetella* spp.), and remains of mackerel (possibly bait from the long-line) and unidentified fish.

RESUMEN

En este trabajo se presenta información sobre el mayor ejemplar de *Ommastrephes bartramii* descrito hasta la actualidad. Se trata de una hembra casi madura, cuya longitud dorsal del manto es de 1020 mm y con un peso total de aproximadamente 35 kg, capturada en octubre de 2007 por un pesquero español utilizando palangre de superficie en el Pacífico Tropical Este. Los incrementos de crecimiento observados en un estatolito indican una edad comprendida entre 492 y 512 días. El estómago estaba lleno y contenía picos de potas (omastréfidos) y de un pulpo pelágico pequeño (*Japatella* spp.), así como restos de caballas (posiblemente cebo del palangre) y de otros peces que no pudieron ser identificados.

INTRODUCTION

The neon flying squid *Ommastrephes bartramii* (LeSueur, 1821) is distributed worldwide in subtropical and temperate oceanic waters (Roper, Sweeney and Nauen, 1984; Nesis, 1987; Dunning, 1998). It has supported major jig and surface driftnet fisheries in the North Pacific since about 1974, and its life history in this area is well known (Bower and Ichii, 2005; Ichii, Mahapatra, Okamura, and Okada 2006). It occurs in the South Pacific where SST

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Figure 1. Worldwide distribution of *Ommastrephes bartramii* (AquaMaps, GBIF OBIS) and capture location (●) of this record.
Figura 1. Distribución mundial de Ommastrephes bartramii *(Aqua Maps, GBIF OBIS) y localización del lugar de captura del ejemplar (●).*

ranges from ~ 12° to 26° C and is rarely caught in cooler waters. Adjacent to the continental slope of western South America, *O. bartramii* is replaced in waters warmer than 15° C by the jumbo squid *Dosidicus gigas* (YATSU AND YAMASHIRO, 1999; ZUEV, NIGMATULLIN, CHESALIN, AND NESIS, 2002). The Subtropical Convergence (SC) is the southern boundary of its distribution in the South Pacific, generally at about 40-50° S. However, the SC zone is highly variable from year to year and shows significant seasonal latitudinal shifts, occurring as far south as 52° S (DUNNING, 1998).

Although this species was identified as a potential fishery resource in the late 1970s, there is still no commercial exploitation in the Southern hemisphere (DUNNING, 1998). NIGMATULLIN, SHCHETINNIKOV AND SHUKHGALTER (2009) sampled 60 specimens of this species, to study the diet and parasites, by jigging in the south-eastern Pacific in the early 1980s. The animals ranged from 16 to 39 cm mantle length (ML). The largest specimen recorded to date was a female of 800 mm mantle length weighing 20-25 kg caught in Argentinean waters (DUNNING, 1998). In this paper we describe a new record of a larger specimen caught in the SE Pacific, including information on age, maturity and stomach contents.

MATERIAL AND METHODS

The present specimen was caught by the Spanish fishing vessel *Nuevo Monte Ventoso*, 10/10/07, on a surface long-line at 21° S, 88° W (FAO area 87, Figure 1). It was frozen on board and transported to Vigo (NW Spain). It was defrosted at room temperature, dissected and measured (see Figure 2). We sampled stomach contents, one statolith (the other was not located), beaks, sucker rings, mantle and ovary tissue.

The method applied for ageing involved mounting the statolith on a microscope slide, using Crystalbond, with the anterior concave side upper-

Figure 2. *Ommastrephes bartramii*, view of the mouth, arms and anterior ventral mantle margin of the specimen.
Figura 2. Ommastrephes bartramii, *vista de la boca, brazos y margen ventral anterior del manto del ejemplar.*

most. The statolith was ground, first on the anterior surface, then turned over and ground on the posterior surface. The statolith was then turned over so that the anterior surface was uppermost. This grinding of both surfaces in the sagittal plane results in the production of a relatively thin statolith section. Increments were determined along the axis of maximum statolith growth with a NIS Elements D 2.30 image analysis system interfaced with a Nikon compound microscope (400x magnification). Counts were obtained semi-automatically: putative increments were detected automatically by computer software from an enhanced image but final identification of increments was carried out manually. Increments were not clearly identifiable near the outer margin of the ground surface, and the number of increments missed in this area was estimated by extrapolation from the adjacent area (GONZÁLEZ, DAWE, BECK AND PÉREZ, 2000).

Stomach contents (consisting of semi-digested flesh and hard remains) were washed through a sieve (mesh size 0.355 mm) and all identifiable prey remains (e.g. fish otoliths, bones and cephalopod beaks) extracted and transferred to 75% alcohol. Fish hard parts were later dried. Beaks, otoliths and bones were identified to the lowest possible taxon using guides (e.g. CLARKE 1986, HÄRKÖNEN 1986; BOSCHI, FISCHBACH AND IORIO, 1992; SMALE, WATSON AND HECHT, 1995; WATT, PIERCE AND BOYLE, 1997; TUSET, LOMBARTE, AND ASSIS, 2008) and reference material held by the authors. Original prey size was calculated from standard measurements (lower rostral length for squid beaks) using published regressions (CLARKE,

Table I. Main measurements (mm for linear measurements, g for weights).
Tabla I. Principales medidas del ejemplar (en mm las morfométricas y en g los pesos).

Linear dimensions	mm	Weights	g
Dorsal mantle length	1020	Total weight	Approx. 35000
Ventral mantle length	970	Nidamental gland weight	250 (1 out of 2)
Ventral mantle width	375	Oviduct gland weight	150 (1 out of 2)
Fin length	500	Ovary weight	500
Fin width	925	Digestive gland weight	950
Arm R1 length	580	Stomach contents weight	950
Arm R3 length	630		
Left tentacle	1020		

1986). In the case of the fish remains, the otoliths found were fragmented. Of the intact fish bones identifiable to family we were able to use the dentary length to estimate the approximate size, using an unpublished regression.

RESULTS AND DISCUSSION

The specimen was a female, with dorsal mantle length (ML) of 1020 mm and weighing around 35 kg. It was almost mature, with mature oocytes passing through the oocyte chamber, and was mated (see Table I). Repeat readings of growth increments on the one statolith located indicate an age of 492-512 days.

Age data from the North Pacific suggest a 1-year life cycle whereas this specimen was already 16-17 months old. However, similar discrepancies between reported age and the known seasonality of the life cycle are known from other squids, e.g. *Loligo* spp. (see González, Otero, Guerra and Pierce, In Press). Bower and Ichii (2005) reported two seasonal cohorts in the North Pacific. In the loliginid squid *Loligo forbesi*, Boyle, Pierce and Hastie (1995) proposed that individual growth rate determines whether an animal becomes a winter or summer spawner, and individuals from summer and winter breeding seasons might thus be of mixed age. Thus an apparently annual spawning and recruitment cycle is not necessarily inconsistent with some animals living for up to 2 years. Chen and Chiu (2003) recorded maximum mantle lengths of 527 mm for *Ommastrephes bartramii* in the North Pacific between September and December, which would be consistent with the present specimen approaching spawning readiness in October.

The stomach was full (containing 950g of food remains, a mixture of semi-digested flesh and hard prey remains). Table II summarises the information on prey found in the stomachs, including reconstructed lengths and weights. Remains included beaks of ommastrephid squids (as well as fragments of gladius and cephalopod flesh), vertebrae, dentaries and a broken otolith from a fish of the family Scombridae, probably a species of mackerel and remains of unidentified fish (broken otoliths, bones, a post-temporal, and numerous dermal scutes). An intact specimen of alfonsino (*Beryx* sp., probably *B. decadactylus*) was recovered from the mantle cavity of the squid (it had not been eaten).

It was not possible to identify the ommastrephid beaks to species since beaks from species in this family are very similar but it is likely that they belong to the same species, since cannibalism is known to be quite common in cephalopods (Ibáñez and Keyl, 2010). The other identified remains of cephalopods belonged to the genus *Japetella*. With the exception of *Japetella*,

Table II. Prey species found in the stomachs of the specimen of *Ommastrephes bartramii* taken by a long-liner in the south-eastern Pacific. For all prey species, number of beaks/other remains, estimated number of individuals (N) and estimated prey length (mm) and weight (g) are indicated.
Tabla II. Especies de presas encontradas en el estómago de Ommastrephes bartramii *capturado con un palangre en el Pacífico sureste. Para todas las especies se indica el número de picos/otros restos, el número de individuos estimados (N) y una estimación de la longitud de la presa (mm) y su peso (g).*

Cephalopod prey Family	Species	Remains	N	Importance Length (mm)	Weight (g)
Ommastrephidae	Unidentified	3 lower + 2 upper beaks, gladius, flesh	3	259-301	536-728
Bolitaenidae	Japatella sp.	1 lower + 1 upper beaks	1	*	*
Fish prey Family	**Species**				
Scombridae	Scomber spp.	Bones + 1 otolith	2	359-385	393-493
Unidentified	Unidentified	broken otoliths, bones, dermal scutes			

which is a small pelagic octopus (specimens of *Japetella* recorded from pygmy sperm whale stomachs in Hawaii averaged 8 g in body weight, West et al. 2009), the estimated size of the prey taken by the squid ranged from 259 to 385 mm in length and 390 to 720 g. The occurrence of mackerel in the diet is at first sight surprising since mackerel is a shelf species, but it may have been used as bait on the long-line (although remains of more than 1 individual mackerel were found in the stomach and bait fish are normally spaced out along a long-line).

There is little information on the diet of the species, NIGMATULLIN, SHCHETINNIKOV AND SHUKHGALTER (2009) reported on the stomach contents of 60 specimens of *O. bartramii* taken by hand-jigging in the southeast Pacific. These squid had taken a wide variety of prey, mainly myctophid fish (*Symbolophorus, Myctophum* and *Hygophum*) and cephalopods (Onychoteuthidae and Enoploteuthidae). The authors also noted the presence in the stomachs of beaks of the family Ommastrephidae (including some remains of *O. bartramii*). Myctophid fish and squid of the families Onychoteuthidae and Enoploteuthidae were also found to be the main prey in a sample of 315 *O. bartramii* from off Hawaii (PARRY, 2006). No myctophid remains were found in the stomach of the present specimen.

The main preys of this species in the Northwest Pacific were myctophids. Secondary important prey items included onychoteuthid and gonatid squids. The study was done using driftnets offshore but *Engraulis japonicus* and Carangidae (as well as other species that could be found in shelf waters) were reported in the diet in low numbers. Chnages in feeding habits of the neon flying squid were found in relation to their seasonal south-north migrations and diel vertical displacements (WATANABE, KUBODERA, ICHII AND KAWAHARA, 2004).

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BIBLIOGRAPHY

Boschi E., Fischbach C. and Iorio M. 1992. Catálogo ilustrado de los crustáceos estomatópodos y decápodos marinos de Argentina. *Frente Marítimo*, 10: 56-57.

Bower J.R. and Ichii T. 2005. The red flying squid (*Ommastrephes bartramii*): A review of recent research and the fishery in Japan. *Fisheries Research* 76, 39-55.

Boyle P.R., Pierce G.J. and Hastie L.C. 1995. Flexible reproductive strategies in the squid *Loligo forbesi*. *Marine Biology*, 121: 501-508.

Chen C.-S. and Chiu T.S. 2003. Variations of life history parameters in two geographical groups of the neon flying squid, *Ommastrephes bartramii*, from the North Pacific. *Fisheries Research*, 63: 349-366.

Clarke M.R. 1986. *A handbook for the identification of Cephalopod beaks*. Clarendon Press. Oxford. 273 p.

Dunning M. 1998. An overview of the fisheries biology and resource potential of *Ommastrephes bartramii* (Cephalopoda: Ommastrephidae) in the Southern Hemisphere. In Okutani, Y. (Ed.): Contributed papers to International Symposium on Large Pelagic Squids. *Japan Marine Fishery Resources Research Center*, Tokyo: 65-76.

González A.F., Dawe E.G., Beck P.C. and Pérez J.A.A. 2000. Bias associated with statolith-based methodologies for ageing squid: a comparative study on *Illex illecebrosus* (Cephalopoda: Ommastrephidae). *Journal of Experimental Marine Biology and Ecology*, 244: 161-180.

González A.F, Otero J., Guerra A., Pierce G. J. (in press) Age, growth and mortality of *Loligo vulgaris* wild planktonic paralarvae in the Ría de Vigo (NE Atlantic Ocean). *ICES Journal of Marine Science.*

Härkönen T. 1986. *Guide to the otoliths of bony fishes of the Northeast Atlantic*. Daubin ApS. Sweden. 256 p.

Ibáñez Ch.M. and Keyl F. 2010. Cannibalism in cephalopods. *Reviews in Fish Biology and Fisheries*, 20: 123-136.

Ichii T., Mahapatra K., Okamura H. and Okada Y. 2006. Stock assessment of the autumn cohort of neon flying squid (*Ommastrephes bartramii*) in the North Pacific based on past large-scale high seas drifnet fishery data. *Fisheries Research*, 78: 286-297.

Nesis K.N. 1987. Cephalopods of the world. Squids, cuttlefishes, octopuse, and allies. T.F.H. Publications, Neptune City. 351 p.

Nigmatullin C.M., Shchetinnikov A.S. and Shukhgalter O.A. 2009. On feeding and helminth fauna of neon flying squid *Ommastrephes bartramii* (Lesueur, 1821) (Cephalopoda: Ommastrephidae) in the southeastern Pacific. *Revista de Biología Marina y Oceanografía*, 44: 227-235.

Parry M. 2006. Feeding behaviour of two ommastrephid squids *Ommastrephes bartramii* and *Sthenoteuthis oualaniensis* off Hawaii. *Marine Ecology Progress Series*, 318: 229–235.

Roper C.F.E., Sweeney M.J. and Nauen C.E. 1984. *FAO species catalogue. Cephalopods of the world. An annotated and illustrated catalogue of species of interest to fisheries.* FAO Fisheries Synopsis, 3 (125): 277 p.

Smale M.J., Watson G. and Hecht T. 1995. *Otolith atlas of Southern African marine fishes (Ichthyological monographs).* J.L.B. Smith Institute of Ichthyology, 1, 253 pp.

Tuset V.M., Lombarte A. and Assis C.A. 2008. Otolith atlas for the western Mediterranean, north and central eastern Atlantic. *Scientia Marina*, 72: 1–203.

Watanabe H., Kubodera T., Ichii T. and Kawahara S. 2004. Feeding habits of neon flying squid *Ommastrephes bartramii* in the transitional region of the central North Pacific. *Marine Ecology Progress Series*, 266: 173-184.

Watt J., Pierce G.J. and Boyle P.R. 1997. A guide to the identification of North Sea fish using premaxillae and vertebrae. Co-operative Research Report No 220, International Council for the Exploration of the Sea, 231 p.

West K.L., Walker W.A., Baird R.W., White W., Levine G., Brown E. and Schofield D. 2009. Diet of pygmy sperm whales (*Kogia breviceps*) in the Hawaiian Archipelago. *Marine Mammal Science*, DOI: 10.1111/j.1748-7692.2009.00295.x

Yatsu A. and Yamashiro C. 1999. *Report of the Kaiyo Maru Cruise for study on the resources of two ommastrephid squids, Dosidicus gigas and Ommastrephes bartrami, in the Pacific Ocean, during September 11 - December 24, 1997*. Fisheries Agency of Japan, 206 p.

Zuev G.V., Nigmatullin Ch.M., Chesalin M.V. and Nesis K.N. 2002. Main results of long-term worldwide studies on tropical nektonic oceanic squid genus *Sthenoteuthis*: an overview of the soviet investigations. *Bulletin of Marine Science*, 71: 1019-1060.